§5. Evaluation of Superconductors for the Helical Coils of Large Helical Device (2)

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Experiments of the superconductor for the helical coils of Large Helical Device (LHD) have been carried out to evaluate its specifications. Critical currents and stability characteristics (such as recovery currents and stability margins) were mainly investigated.

Figure 1 shows the measured critical currents and recovery currents against the bias magnetic field. The measured critical currents (20 kA at the bias field of 7 T) were in good agreements with predicted values (indicated by the dashed curve in Fig. 1), in which a measured critical current for one strand is used. In the prediction, self-field effect of twisted strands has been precisely calculated by taking account of the 3-D location of each strand and also of the longitudinal distribution of the bias magnetic field.

As for the cryogenic stability, one of the main results is that we have obtained recovery currents which exceed 13 kA at 7 T with the external magnetic field parallel to the 18 mm surface. We consider this is owing mainly to the adoption of Cu-2%Ni for the clad material around the aluminum stabilizer. It was theoretically predicted that a resistive layer around the pure aluminum reduces the Hall effect[1], decreases the magnetoresistivity of the stabilizer and hence improves the recovery current. We confirmed this effect from the measurements of longitudinal voltage after transitions to the normal state. Figure 2 shows that the measured effective resistivity of the stabilizer (at 7 T) lies in the range of twice the value without considering the Hall effect. In the case of using a conventional OFC as a clad material for the same configuration (named KISO-33 conductor), the effective resistivity becomes more than three times larger than the values with Cu-2%Ni clad[2]. Measured normal resistivities and measured heat transfer coefficients from an oxidized copper surface to liquid helium have enabled us to examine the measured recovery currents with Maddock's theory. The dotted curve in Fig. 2 shows the calculated result. One of the reasons for the slight difference between the measured and the calculated values may be finite length effect of the external magnetic field.

Through the series of present experiments, we could say that an evaluation method for pool-cooled conductors have been established with our facilities. One of the recent improvements is the adoption of RuO_2 and ZrO_2 resistive thermometers[3] for temperature measurements because of their less dependence on magnetic field.

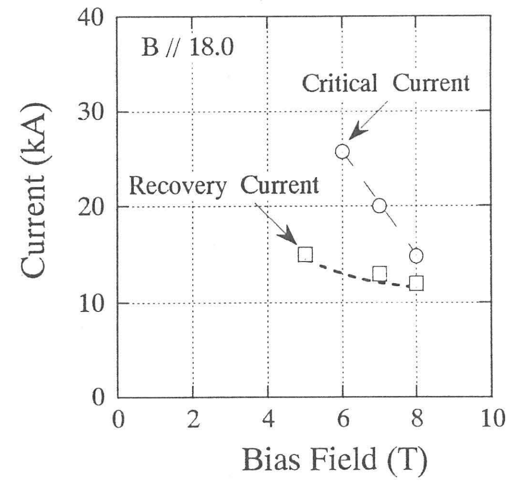

Fig. 1. Measured critical current and recovery current. Calculated values are also shown for each specific current.

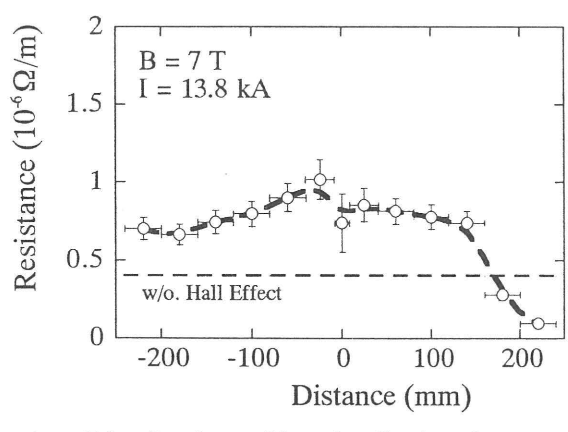

Fig. 2. Distribution of longitudinal resistance after a transition to the normal state.

References

1) Kaneko, H. : Cryogenics **33** (1993) 1077.
2) Yanagi, N., Mito, T., Takahata, K., et al., : Advances in Cryogenic Engineering-Materials **40** (1994) 459.
3) Yamaguchi, S. : private communications.